NORTH DAKOTA GEOLOGICAL SURV
UNIVERSITY, N. DAK.
UND CHESTER FRITZ LIBRARY
3 3100 00793 0992
Wis
WS81
QE
179
.A3
Perio
Geol

SIXTH BIENNIAL REPORT

OF THE

COMMISSIONERS

OF THE

Geological and Natural History Survey

Covering the Period from

July 1, 1906, to June 30, 1908.

NORTH DAKOTA GEOLOGICAL SURVEY
LIBRARY
GRAND FORKS, N. D.

MADISON, WIS.
DEMOCRAT PRINTING CO., STATE PRINTER.
1908

W81

SIXTH BIENNIAL REPORT

OF THE

COMMISSIONERS

OF THE

Geological and Natural History Survey

Covering the Period from

July 1, 1906, to June 30, 1908.

NORTH DAKOTA GEOLOGICAL SURVEY
UNIVERSITY, N. DAK.

MADISON, WIS.
DEMOCRAT PRINTING CO., STATE PRINTER.
1908

TABLE OF CONTENTS.

Board of Commissioners 4

Staff of Survey 5

Letter of Transmission 7

Report of Director 9

- Personnel of Survey 9
- Financial Statement 11
- Work of Survey 12
  - Areal Geology 13
  - Water Powers 16
  - Lakes 17
  - Fish 19
  - Highways 21
  - Lead and Zinc District 24
  - Peat 27

Publications 27

Future Work 28

Appendix—Financial Report 34

Statutes relating to Survey 38

List of Publications 42

GEOLOGICAL AND NATURAL HISTORY SURVEY.

BOARD OF COMMISSIONERS.

JAMES O. DAVIDSON,
Governor of the State.

CHARLES R. VAN HISE, *President.*
President of the University of Wisconsin.

CHARLES P. CARY, *Vice President,*
State Superintendent of Public Instruction.

CALVERT SPENSLEY,
President of the Commissioners of Fisheries.

LOUIS KAHLENBERG, *Secretary,*
President of the Wisconsin Academy of Sciences, Arts, and Letters.

STAFF OF THE SURVEY

ADMINISTRATION:

EDWARD A. BIRGE, Director and Superintendent. In immediate charge of Natural History Division.
F. G. SANFORD, Clerk.

GEOLOGY DIVISION:

T. C. CHAMBERLIN, Consulting Geologist, Pleistocene Geology.
WILLIAM O. HOTCHKISS. In charge, Economic Geology.
SAMUEL WEIDMAN. In charge, Areal Geology.
EDWARD B. HALL. Assistant, Areal Geology.
FREDERICK T. THWAITES. Assistant, Areal Geology.
*GUY C. COX. Assistant, Economic Geology.
*LAWRENCE MARTIN. Assistant, Physical Geography.
*FREDERICK W. HUELS, Assistant, Report on Peat.

WATER POWER DIVISION:

LEONARD S. SMITH. In charge.

HIGHWAY DIVISION:

WILLIAM O. HOTCHKISS. In charge.
ARTHUR R. HIRST. Highway Engineer.
MARTIN W. TORKELSON. Bridge Engineer.
HERBERT J. KUELLING. Assistant Highway Engineer.
WALTER C. BUETOW. Assistant Bridge Engineer.
WAYLAND C. WELLS. Clerk.

NATURAL HISTORY DIVISION:

CHANCEY JUDAY. Lake Survey. In charge of field parties.
GEORGE WAGNER. Report on Fish.
*ROY D. HALL. Assistant, Lake Survey.
*GEORGE KEMMERER. Assistant, Lake Survey.
*MELVIN E. DIEMER. Assistant, Lake Survey.
*CHARLES T. VORHIES. Assistant, Report on Fish.
*HARTLEY H. T. JACKSON. Assistant, Report on Fish.
*JESS G. MAXON. Assistant, Report on Fish.

* Assistants employed during the field season of 1908.

LETTER OF TRANSMITTAL,

COMMISSIONERS OF THE WISCONSIN GEOLOGICAL AND NATURAL HISTORY SURVEY, MADISON.

Office of the President.
October 1, 1908.

HONORABLE JAMES O. DAVIDSON,
Governor of the State.

SIR:—I have the honor to transmit herewith the report of Dr. E. A. Birge, Director and Superintendent of the Geological and Natural History Survey for the biennial period extending from July 1, 1906, to June 30, 1908, including also a general statement of the work performed by the Survey during the summer and fall of 1908. During this period the regular appropriation for the Survey has been $10,000, and the legislature of 1907 made a special appropriation of $10,000 annually for two years, to be devoted to the extension of the work on water powers, Southwestern Wisconsin, and especially highways. The amount granted and the necessities of the last department were such that no money has been expended on water powers, and most of this appropriation has been devoted to highways.

The Survey has continued its work in all departments, and has issued several important publications during the biennial period, which are described in the report of the Director. From the scientific point of view, the most important publication during the past two years has been the report on the geology of north central Wisconsin by Dr. Weidman. From the economic point of view, the most important bulletin is that by Professor L. S. Smith on the water powers of the State. A very large part of the funds of the Survey since the adjournment of the Legislature of 1907 have been devoted to the subject of roads. The efforts of the Survey in behalf of the roads of the State have included several branches. The most important of these have been educational work carried on at special meetings, and particularly in

connection with the farmers' institutes, work in the preparation of plans and specifications for bridges, and the building of experimental roads. Much commendation is due to Mr. Hotchkiss and his associates in this department for the wisdom and the skill which they have shown, and for the large results which they have obtained from the comparative small fund at their disposal. If the constitutional amendment, permitting state aid to roads, is approved by the people in November, that result, so earnestly to be wished, will be in great part due to the efforts of this Survey, which years ago began its work in behalf of the roads of Wisconsin.

Of other matters mentioned in the Director's report I will refer only to the work of the Survey upon lakes. The investigations which are now nearly ready for publication have been carried on slowly, as is necessary with studies which are dealing with fundamental problems. They have already shown their practical value, however. One evidence of such is found in the fact that the United States Bureau of Fisheries has cordially coöperated with the Survey, aiding in the extension of these observations.

The report of the Director shows that there still remain many matters of importance in which the Survey can profitably serve the State. The consciousness of the people has been recently awakened to the fact that the large resources accumulated by nature in the past have been drawn upon far more rapidly than they are renewed, and that future prosperity will depend on an intelligent, and even scientific utilization of these resources. The appointment by the Governor of a Commission on the Conservation of the Natural Resources of Wisconsin is one evidence of this fact. The establishment of this Survey eleven years ago is, perhaps an even better evidence of this wisdom and foresight of the State, in making some, even though not wholly adequate, provision for the investigation of these resources. It is certain that in the future the value of the work of the type which this Survey has been and is carrying on will be more and more clearly seen. I believe it is certain that the State will demand its extension into many new directions, and that large profit will come from this source to the commonwealth.

Very respectfully yours,

CHARLES R. VAN HISE,

President.

REPORT OF THE DIRECTOR OF THE SURVEY.

To the Commissioners of the Geological and Natural History Survey:

GENTLEMEN:—I submit herewith my sixth biennial report as Director and Superintendent of the Survey under your charge from July 1, 1906, to June 30, 1908. I include also a statement of the work of the Survey during the summer of 1908; thus giving an account of its operations up to the time when the report goes to press.

The regular income of the Survey during the biennial period has been $10,000 annually; the same as during the period covered in the preceding report. By chapter 641 of the laws of 1907, the additional sum of $10,000 annually was appropriated for two years in order to carry on investigations regarding roads, water powers, and to extend the mapping of the lead and zinc district. The Survey also received aid to the amount of $500 in 1907 from the United States Bureau of Fisheries, to assist in lake investigations, and $250 in the same year from the Wisconsin Commissioners of Fisheries, to aid in defraying expenses of making a collection of Wisconsin fishes. These appropriations have been continued during 1908.

I. PERSONNEL OF THE SURVEY.

The following table shows the organization of the Survey, with the names of the persons who have been employed during the past two years. The amount of money paid to each person, including compensation and allowance for field expenses, is included in the report of the Secretary of State.

Administration:

EDWARD A. BIRGE, Superintendent and Director of the Survey. In immediate charge of Natural History Division.

F. G. SANFORD, Clerk.

Geology Division:

T. C. CHAMBERLIN, Consulting Geologist, Pleistocene Geology.

WILLIAM O. HOTCHKISS, Geologist. In charge of Economic Geology and of Highway Division. Gave part time to Survey until July 1, 1907; full time since that date.

SAMUEL WEIDMAN, Geologist. In charge of Areal Geology.

EDWARD B. HALL, Geologist. Assistant in Areal Geology. Employed during field season of 1906 and year 1907–08.

Field party, Southwestern Wisconsin; summer of 1907:

EDWARD STEIDTMANN, Geologist. In charge.
DANIEL F. HIGGINS, Geologist.
CHARLES E. DECKER, Geologist.
FRANK F. GROUT, Geologist.
SIDNEY H. DAVIS, Levelman.
HUBERT A. STECKER, Levelman.
EDWARD C. STOCKER, Levelman.
EWALD O. STIEHM, Rodman.
WILLIAM H. HINN, Rodman.
GEORGE P. STOCKER, Cook, etc.

Highway Division:

WILLIAM O. HOTCHKISS. In charge.

ARTHUR R. HIRST, Highway Engineer. Employed since August 15, 1907.

MARTIN W. TORKELSON, Bridge Engineer. Employed since February 15, 1908.

HERBERT J. KUELLING, Assistant Highway Engineer. Employed since May 5, 1908.

WAYLAND C. WELLS, Clerk and Stenographer.

Natural History Division:

CHANCEY JUDAY, Biologist. In charge of Lake Survey. Absent Oct., 1907, to July, 1908.

GEORGE WAGNER, Biologist. In charge of Report on Fishes. Field work, done mainly in summer of 1907.

Field Assistants, summer of 1906:

RAYMOND C. BENNER, Chemist. Lake Survey.
CHARLES T. VORHIES, Assistant. Fish Report.

Field Assistants, summer of 1907:

ROY D. HALL, Chemist. Lake Survey.
CHARLES T. VORHIES, Assistant. Fish Report.
GEORGE KEMMERER, Assistant. Lake Survey.
EARL V. HILLS, Assistant. Lake Survey.

Water Power Division:

LEONARD S. SMITH, Engineer. In charge. Small amount of field work in biennial period. Report written and published.

Besides the persons named above, others have been employed for special services and for short periods as stenographers, draftsmen, and in similar temporary capacities.

II. FINANCIAL STATEMENT.

In the following table I have summarized the expenditures of the Survey according to departments, thus indicating the main directions in which the money appropriated by the State has been expended. The result is as follows:

	1906–07	1907–08
Administration	$856.00	$1,092.03
Areal Geology	3,435.47	3,986.80
Southwestern Wisconsin	60.61	.....
Water Powers	296.72	.....
Economic Geology	2,087.35	2,635.40
Lake Biology	2,046.39	1,046.43
Lake Chemistry	610.78	540.97
Report on Fish	481.64	267.91
Special	118.55	568.15
	$9,993.51	$10,137.69
Water Powers (Chapter 475, Laws of 1905)	$265.91	.....
Roads (Chapter 641, Laws of 1907)	.....	$6,132.72
Southwestern Wisconsin (Chapter 641, Laws of 1907)	.....	2,587.43
		$8,720.15

The expenses for administration include the Director's salary, $500, the pay of the clerk, and expenses for stationery, postage, printing, freight and express, etc., which are not chargeable to special investigations. In each of the years covered by this report the Director spent the entire summer—about three months—in field, office, and laboratory work associated with the natural history investigations of the Survey.

The sums as given in the statement above do not agree with the totals from the table furnished by the Secretary of State. The figures in my report refer to claims audited at this office during the period covered by the report, and always include some claims at the close of the year not included by the Secretary of State, and omit at the opening of the year others included by him. The Secretary of State also includes in his report items paid from the general fund for printing and engraving.

III. WORK OF THE SURVEY

The report of the work of the Survey for the past biennial period naturally falls into two divisions:

1. The investigations carried on under the present permanent appropriation of the Survey.

2. The new work made possible by the special appropriation granted by the legislature of 1907.

1. A. The most important piece of work completed during the biennial period has been Dr. Weidman's report on the Geology of North Central Wisconsin, and the extension of his survey to the northwestern part of the state.

B. The field work for a report on the water powers of the state was finished in 1906 and the report by Professor L. S. Smith has been published. There still remain a number of important rivers to be surveyed.

C. Investigations on the lakes have been continued and have been aided by a grant from the United States Bureau of Fisheries.

D. The collection of fishes, to serve as a basis of a report on Wisconsin fishes of economic value, has been continued, aided by a grant from the Wisconsin Commissioners of Fisheries. With the work of the season of 1908 collections have been made from all regions of the state sufficiently large to enable a beginning to be made on the study of the distribution of the fish.

2. The most important items of work undertaken by means of the grant of the legislature of 1907 are:

E. The work of the Highway Division. This division, the largest and economically the most important division of the Survey, has received by far the greatest part of the money appropriated by the state. The financial report shows that during the year 1907 more than $6,000 were spent on this division. In addition, the salary of Mr. Hotchkiss, $2,500, ought also to be credited to this division, although paid from the regular appropriation. The expenses of this division increased as the year advanced and a balance of some $1,300 was carried over from 1907–08 to 1908–09. Within the two years covered by the appropriation the sum of nearly $20,000 will be spent on the roads.

F. During the summer of 1907 a field party was maintained in

Southwestern Wisconsin, enlarging the area mapped. The drawing of the maps was completed during the following winter and they are now in process of engraving.

G. Under special investigations the most important is a report on the fossils of the Devonian formation of Milwaukee, by Professor H. F. Cleland of Williams College. The Survey bore the expense of preparing this report; the expense of the field work being borne by Professor Cleland. The report is now completed and ready for publication.

H. During the present summer the Survey has carried on work in all of the permanent lines indicated above. The work of the Highway Division has been vigorously prosecuted. The field work on the areal geology has been carried on by Dr. Weidman with two field assistants: Mr. Hall and Mr. F. T. Thwaites. Collections of fish were made in the northwestern part of the state and in the Lake Superior region by Messrs. Vorhies, H. H. T. Jackson, and J. G. Maxon. The field work for the study of the Wisconsin lakes was completed by an investigation of the lakes of the northwestern part of the state by Messrs. Juday, Hall, Kemmerer, and M. E. Diemer. Professor L. Martin spent the summer in the study of the physical geography of the state, primarily to prepare a chapter on this subject for the general account of the geology of Wisconsin. Mr. F. W. Huels carried on field work on the peat deposits of the state. The testing of the samples collected will be done by the United States Geological Survey. Mr. G. H. Cox carried on field work in the lead and zinc district of Southwestern Wisconsin, giving especial attention to the problems associated with the origin and deposition of the ores.

The following pages report the work of the Survey in greater detail:

A. *Areal Geology.* The survey of the north central counties of the state by Dr. S. Weidman was completed in 1906, and the report on that district, Bulletin No. 16, a volume of 697 pages, entitled "The Geology of North Central Wisconsin," was ready for distribution in September, 1907. The area described in this report, (see map page 11), includes Portage, Wood, Clark, Marathon, Lincoln, and Taylor Counties, with adjoining portions of Langlade, Price and Rusk Counties. The area has an approximate extent of 7,200 square miles, about one-eighth of the state.

A report of the north central counties, Bulletin No. 11, with

accompanying soil map was issued in 1903. Owing to the large demand for this soil report by those interested in the agriculture of northern Wisconsin, the first edition of this report, 6,000 copies, was exhausted. A second edition of the soil report, 3,000 copies, was printed in September, 1908.

During the past four years the areal survey of the counties west of the north central part of the state has been in progress. This part of the state may be conveniently referrerd to as Northwestern Wisconsin. It includes (see sketch map) Eau Claire,

Map showing location of North Central Wisconsin district.

Chippewa, Rusk, Barron, Dunn, Pepin, Pierce, St. Croix, and Polk counties. It is planned to prepare reports on the soil and geology of this area similar to those of North Central Wisconsin.

During this season of 1905 Dr. Weidman was assisted in the field survey of Northwestern Wisconsin by J. H. Warner and E. B. Hall. About four months were spent in the field work and

parts of Rusk, Barron, Chippewa, and Eau Claire Counties, were surveyed.

In 1906 Mr. Hall continued as assistant, and about six months were spent in the field. The remaining parts of Eau Claire and Barron Counties, and the whole of Dunn County were surveyed.

In 1907 about six months were spent in the field by Dr. Weidman and Mr. Hall, and the survey was mainly confined to Pierce and St. Croix Counties.

During the present season of 1908 Pepin and Polk Counties were surveyed. Part of the season also was given to the final preparation of the soil map of the entire area. During 1908 E. B. Hall and F. T. Thwaites assisted in the field work.

During 1906 and 1907 an informal cooperation in the survey of the glacial formation was carried out with Mr. Frank Leverett of the U. S. Geological Survey. The survey of the glacial formation of the central part of the United States is under the general supervision of Prof. T. C. Chamberlin, who is also consulting geologist of the State Survey on glacial geology. The relative positions of the glacial formation of Wisconsin with respect to similar formations in the adjoining states of Illinois, Minnesota and Iowa are not at present known, and it is planned to continue cooperation until the correlation of the glacial formation can be determined. During the present year, 1908, there has been an informal cooperation with the Minnesota geologists, Professors Hall and Sardeson, in the survey of the formation along the Mississippi River.

During the present field season of 1908 an informal cooperation has been carried out in the soil survey with Prof. A. R. Whitson of the University Agricultural Department. In this scheme of cooperation Prof. Whitson and assistants plan to make special investigation of the various soil formations as mapped by Dr. Weidman in the regular areal and soil work of the Survey. In Prof. Whitson's work emphasis is therefore laid on investigations of the chemical and physical character of the various soil formations, especially those already opened up to agriculture, their relative fertility and value for special crops, the best means of soil improvement, the conservation of the soil resources, and various other important agricultural problems relating to the soil.

Soil reports of the northern half of the state, in view of the

large proportion of unsettled land in that part of the state, should, perhaps, be prepared with two principal objects or purposes in view. On the one hand the soil report and maps should be prepared for the prospective new settler, and for this purpose a brief report, with soil map, giving accurate and unprejudiced information, the soil report of north central Wisconsin, No. 11, is amply sufficient. But, on the other hand, to the farmer already settled upon the land, information concerning the character, fertility, and conservation of his soil cannot be too detailed, and for him the soil report should be of greater length, and should deal with the special problems of agriculture which have already, or will shortly develop upon the particular soil formations where he has made his farm.

In making the soil survey of the northern half of the state, therefore, a formal cooperation in the areal geology and soil mapping of the Survey with the work in soil investigation by the University Agricultural College could wisely and conveniently be carried out. To aid in this important work, which is clearly a principal object for which the State Survey was organized, additional funds for the areal and soil survey are needed. At the present time funds for the areal geology are hardly sufficient for the survey of about two counties, 40 to 50 townships, per year. This work should be so increased that at least two or three times the present area can be covered each year. Even at this increased rate it would require at least five or six years to complete the soil map of the northern half of the state.

B. *Water Powers.* The field work for the report on the water powers of the state, authorized by chapter 475 of the laws of 1905, was completed in the first months of the biennial period covered by this report. On the completion of the field work Professor L. S. Smith began the preparation of the report, which was published in 1908 in a volume of 354 pages with 54 plates. This report gives a very full and completely illustrated account of the water powers found in many of the most important rivers of the state. The report is unusually well presented and the facts regarding each river have been investigated and reported on with exceptional care. As stated in my last biennial report, the work has been done at much less expense than attended water powers surveys much less complete and satisfactory. The report has received great praise from all interested in this subject, both in

this state and from engineers without the state who have examined it.

Besides the report, Professor Smith prepared profile maps of the most important rivers of the state. These include the Wisconsin River, in 11 sheets; the Eau Claire River, 2 sheets; the Peshtigo River, 4 sheets; the Black River, 3 sheets; and the Flambeau River, 6 sheets. These have been published by the United States Geological Survey and can be obtained either from that Survey or from the Wisconsin Survey at a uniform price of five cents per sheet.

C. *Lakes.* The study of the lakes has been continued along lines indicated in the Fifth Biennial Report, which gave an account of the progress of the work up to the fall of 1906. Investigations were vigorously carried on during the year 1906–07 and until October, 1907, when Mr. Juday, the biological assistant, was given leave of absence until July, 1908, in order that he might visit biological laboratories in Europe. During his absence little work was done, as there was no one in the employ of the Survey who could continue it, and active operations were resumed again in July, 1908. Thus, with the exception of the months of Mr. Juday's absence, field and laboratory work have been carried on continuously in this subject since the fall of 1904, and the material is now in hand for a report on the subject, which it is hoped will be written during the current year and published at once.

Several principles and beliefs have underlain this part of the work of the Survey. It is believed that the numerous lakes of Wisconsin constitute one of the most important natural resources of the State,—a resource which at present is valuable, both as adding food supply and especially as contributing to the wealth of the state through the attractions which they offer for summer visitors and for sport. It is believed also that a full knowledge of the fundamental conditions of life in these lakes is a matter of the first importance to a proper utilization of these resources and that the acquisition of this knowledge will make possible an increase in the value of this property to the State. This knowledge holds the same relation to the economic use of lakes as does that of soil physics and chemistry to the use of agricultural land. When the Survey began work such knowledge was almost wholly lacking. European investigations were very scanty and fragmentary and very little had been done in this country, and that

consisted of scattered observations, chiefly made in connection with the study of water supplies. As these studies were almost wholly new, they have necessarily proceeded slowly, especially as the funds at the disposal of the Survey were small, and the work has suffered at least one long interruption for lack of money.

During the earlier years of the Survey these studies were carried on by the Director alone, whose efforts aimed at finding out the temperature conditions of the lakes, which form, to a great degree, the key to the understanding of other facts which modify the conditions of lake life. A report on this subject was written several years ago but pressure of other matters has deferred its publication. With the fall of 1904, work was begun by Professor Lenher of the Department of Chemistry in the University, under the supervision of the Director, on the dissolved gases of the lakes. Methods were worked out during the fall and winter and serious investigations were begun in the spring of 1905. With the return of Mr. Juday in August, 1905, the main labors of the investigation were committed to him. During 1905 and 1906 the lakes of Southeastern Wisconsin, from Waupaca to Lake Geneva, were studied in the field. It soon appeared that these studies were revealing facts which profoundly affect the the kind and amount of life which various lakes can support, and some practical conclusions regarding the possibilities of fish life in the deeper water of lakes soon became apparent. The reports made of these studies to the members of the United States Bureau of Fisheries at Washington so interested them that the Bureau offered to cooperate with the Survey and aid it to carry on these studies on a larger scale. During the years 1907 and 1908 the Bureau of Fisheries has contributed $500 annually to the extension of the field work. In 1907 studies were made on the lakes of northeastern Wisconsin, and during 1908 on the lakes of the northwestern part of the state. Nearly sixty lakes were visited in each section during the month of August and the early part of September. Experience has shown that this is the critical period for lakes in respect to the possibilities of life in the deeper waters, as the oxygen content of the lower water is lowest at this time. The general history of the lake during the year can be inferred from obsrvations made in late summer when this cycle has been worked out during the entire year in a considerable number of lakes which can serve as standards.

The Survey has thus brought material for a much more complete report on the fundamental conditions of life in lakes than has ever been collected before. The course of the investigations also has made it plain that the demands of the future are rather for a careful and consecutive study of the facts in single lakes carefully selected as types, than for more numerous observations scattered widely over different lakes. The importance of the facts which have been ascertained has become increasingly plain, and as would be expected, the difficulty and the complexity of the study have appeared also. The physical and chemical problems of lake biology are nearly as complex and difficult as are those of the soil and need to be studied by the same careful, patient, continuous and extensive methods. The report of the Survey will constitute an introduction to such work. It will sketch the general facts of the physical and chemical conditions of life in lakes, but it will suggest far more problems than it will be able to solve.

During the biennial period four brief papers have been published relating to various points that have come out in connection with this work:

On the Oxygen Dissolved in the Waters of Wisconsin Lakes, E. A. Birge. Read at the 35th meeting of the American Fisheries Society, 1906. Published in their Transactions and in the report of the Wisconsin Commissioners of Fisheries for 1904–06.

The Respiration of an Inland Lake, E. A. Birge. Address at the 36th meeting of the American Fisheries Society, 1907. Printed in their Transactions and in the Popular Science Monthly for April, 1908.

On a Summer Resting Stage in the Development of *Cyclops bicuspidatus* Claus. E. A. Birge and Chancey Juday.

Some Aquatic Invertebrates which live under Anaerobic Conditions, Chancey Juday. Both the last papers were published in the Transactions of the Wisconsin Academy of Sciences, Arts, and Letters. Vol. XVI, Pt. 1. 1908.

Besides the Director and Mr. Juday, the following persons have been members of the regular parties which have carried on the field work of this investigation during the past two summers: Messrs. R. C. Benner, R. D. Hall, George Kemmerer, E. V. Hills, and M. E. Diemer.

D. *Fish.* The collection of material for a report on the fishes of the state, commenced in 1905, has been continued. The

greater part of the season of 1906 was spent in the counties bordering on Lake Michigan, and on this lake itself. A short trip was also made into Florence County, and another into the region around Minocqua. As a result of the experiences of this last trip, the entire season of 1907 was spent in and near Vilas County, and special attention was paid to the whitefishes and trout of this region. In consequence we now know definitely four Wisconsin Lakes which contain lake trout in large numbers: Trout Lake, Little Trout Lake, and Black Oak Lake, all in Vilas County; and Long Lake, in Forest County. The evidence seems convincing that in all four lakes the trout are native. A comparison of chemical and physical conditions of them, as worked out by the Survey, ought, therefore, to be of particular interest. During the winter of 1907–8 the collections of white fishes made were carefully worked over. One fact definitely established was the occurrence of the tullibee (Argyrosomus tullibee) in several lakes of the state. This species is an excellent food fish, and seems to thrive under quite varying conditions. It seems therefore a promising form for introduction into such waters as Lake Winnebago and Lake Pepin, where commercial fisheries are important. The successful introduction of a whitefish into Lake Pepin would be an achievement of very great importance. Otherwise our whitefish collections have proved rather puzzling. It is evident that we must secure large collections of well-preserved specimens from all Wisconsin lakes that contain whitefishes, before it is possible to decide what species occur, as the individual variations are so great.

Part of our collections of whitefishes was sent to the Bureau of Fisheries at Washington for comparison, but it proved as puzzling to them as it did to us.

The season of 1908 was started with work in the counties on the western side of the state, to be followed up by a collecting trip to the shores of Lake Superior.

During the field seasons of 1906 and 1907 this work was in charge of Mr. George Wagner, assisted by Mr. Charles T. Vorhies.

Two short papers have been prepared and published by Mr. Wagner as a result of this work: Dissolved Oxygen as a Factor in the Distribution of Fishes. Transactions Wisconsin Academy of Sciences, Arts and Letters. Vol. XVI. Pt. I. 1908. On

the Distribution of *Argyrosomus tullibee.* Presented at the meeting of the American Fisheries Society, Washington, September, 1908.

E. *Highways.* Shortly before the beginning of the period covered by this report Mr. Hotchkiss was appointed to take charge of economic geology, giving half his time to the Survey and half to the University. He took up the study of road conditions in the state and prepared a report on "Rural Highways of Wisconsin" which was very widely distributed. This report helped to stir up a great amount of public opinion in favor of better roads throughout the state. This aroused public opinion moved the legislature of 1907 to make a special appropriation for the economic work of the Survey. The bill as drawn provided for work on the water powers of the state, work in the lead and zinc district, and more particularly for work on country roads. Owing to the fact that the sum finally appropriated was less than the amount provided for in the bill as introduced it became necessary to diminish the work planned for the lead and zinc district, and on water powers.

Chapter 641 of the Laws of 1907 directs the Survey to carry on certain experimental and advisory work in relation to highways and bridges. In order to best carry out the provisions of this act the Highway Division was organized and Mr. Hotchkiss put in charge of the work with the title of Chief of Highway Division. Previous to the passage of this act Mr. Hotchkiss had been doing work in relation to highways and published in January 1907 a bulletin on "Rural Highways of Wisconsin" (Bull. XVIII Economic Series No. 11). The bulletin is outlined in my last Biennial Report.

In organizing the work of this division the services of Mr. Arthur R. Hirst were secured as Highway Engineer assistant, and later Mr. M. W. Torkelson was secured as bridge engineer assistant.

The act was interpreted to provide for educational work in helping the people of the state to avoid the waste which is so apparent in most of the road work being done at present. In describing the work of the highway division it will therefore be given under the three headings—Roads, Bridges and Educational.

Roads. The work on roads has been both advisory and demonstrational. In advising local authorities on how to get the best results for their money sixty-three localities in thirty dif-

ferent counties have been visited. These visits have only been made after an application was filed by the local authorities, and it has not been possible to visit all places applying.

In the demonstration work the highway division has taken actual charge of the construction of roads built with local funds in order to show the best methods to use. The division has been fortunate in securing the loan of steam road rollers and rock crushers from the manufacturers to use on the stone and gravel roads built under their supervision. During the season of 1908 they have at work three rollers and one rock crusher which are loaned by the makers. Such demonstration roads were built at the State Fair, and near the village of Hanover in 1907, and in 1908 the highway division has such roads either completed or under way near Baraboo, Lake Mills, Colfax, Kenosha, Tomah, three near Sparta, and several in Ashland county. Mr. H. J. Kuelling was appointed as temporary assistant for the summer of 1908.

Surveys have been made for laying out new roads or for cutting down hills in many places where the highway division has not been able to take charge of the construction.

This work, both the advisory and demonstrational parts, has resulted in a very noticeable improvement in methods of road construction in every place visited. The effort has been made to make all the steps in construction as plain and simple as possible, and to arouse the interest of the people in getting better results for their money.

Bridges. Very little bridge work was attempted until the calls upon the highway division became very insistent in the late months of 1907. Mr. E. E. Parker was employed as temporary assistant and made a number of trips to get local data necessary to make the designs and give the assistance called for. After a careful consideration of the question it was decided that much good could be accomplished by establishing standard designs and assisting local officials to get truly competitive bids. Under the system in vogue each bridge agent attending a letting usually had a plan of his own and the officers had no one who was not interested in selling them a bridge to give them advice. The plan evolved was to prepare standard plans and specifications and let the local officers use these as a basis on which to call for sealed bids. These, being all on the same plans and specifications, could

be easily compared and the cheapest one selected. In short, the plan was to apply standard engineering methods to the letting of country highway bridges.

Mr. M. W. Torkelson was secured by Mr. Hotchkiss for this work and later Mr. W. C. Buetow was appointed as his assistant. Mr. Torkelson has, with the assistant of Professor Turneaure, Mr. Hotchkiss and Mr. Hirst, prepared a set of standard bridge specifications. He has also prepared standard plans for concrete culverts and bridges from 3 feet to 30 feet span, and standard plans for steel bridges of rom 30 to 175 feet span. The series of plans is not complete as it has been impossible to make designs any faster than the new work demanded, so there are many gaps to be filled in as time permits.

In carrying on the bridge work 102 bridge sites in 33 counties have been inspected and surveyed and plans furnished. This work has been very much appreciated by local authorities and more applications have been received than it has been possible to fill.

Educational. In organizing the highway division Mr. Hotchkiss considered that the most important part of the work would be educational. The people of the state are wasting hundreds of thousands of dollars of road taxes yearly, and the most helpful thing that could be attempted would be to arouse a general interest in the subject and so get more value for the money expended. It was necessary to impress on them that they did not need to spend more money on roads so much as they needed to spend what they already had in an efficient manner.

In pursuing this end Mr. Hirst was instructed to prepare four brief pamphlets on the following subjects: No. 1, Earth Roads; No. 2, The Earth Road Drag; No. 3, Stone and Gravel Roads; No. 4, Culverts and Bridges. These pamphlets were very widely distributed and stirred up a great amount of interest. They were written in very plain simple style and have attracted much favorable comment from the engineering magazines. Requests have been received for them from every continent of the world except Europe, and good roads associations in other states have issued reprints of them. The pamphlets were distributed at all farmers' institutes held during the winter of 1907–8 and at numerous other gatherings. They were sent to all town chairmen and rural carriers, the Postmaster General furnishing the address of all carriers for this purpose. Many of the carriers and

other interested persons have asked for copies to distribute to aid them in their efforts to arouse local interest in better roads.

In carrying on this educational work Mr. Hotchkiss and Mr. Hirst have given talks at many gatherings. All the farmers' institutes, with a few unavoidable exceptions, were addressed and much interest manifested. Special Good Roads meetings organized by Town Officers, Postmasters, Business Men's Associations, County Boards, Editors, and others have been attended and practical talks given. Altogether 107 meetings aggregating nearly 20,000 people have been addressed. These meetings were distributed over 53 counties.

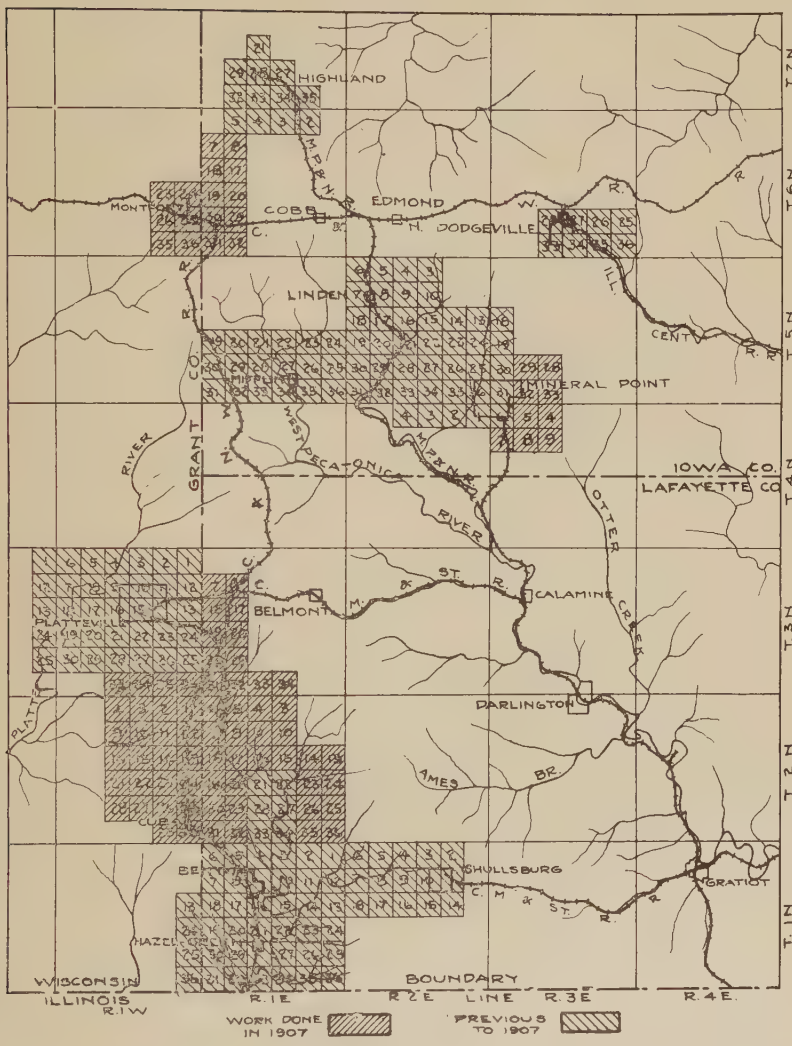
As a result of these meetings and the pamphlets distributed there are many split log drags in use in the state. Several individuals and associations (business men, fair boards, and others), have been influenced to offer prizes for the best roads built in their vicinity with the drag.

Altogether the work of the highway division has reached 272 localities and every county in the state but six. The work has not been limited by the demands made for assistance, as these demands have been have been more than the division has had time to meet; it has only been limited by the amount of money available for the purpose.

In addition to the regular work of the highway division Mr. Hotchkiss organized the State Good Roads Association of which he is secretary. This association has collected funds to aid in securing the passage of the constitutional amendment to permit this state to aid in building roads, under a system similar to that adopted in most of the other progressive states.

Mr. Hotchkiss has also given a free course in Road Building in connection with the correspondence department of the University. This course has been taken by about 150 officers in charge of road work in the various towns and villages.

F. *Lead and Zinc District.* When the money appropriated by chapter 641 of the Laws of 1907 became available Mr. Hotchkiss organized a field party to extend the work of the Survey over the new areas to which exploration had extended. In this work 94 square miles were mapped on a scale of 4 inches to the mile with 10-foot contours. The maps are in the engravers hands and will soon be ready for issue. They give the depth below surface of the important ore bearing formations, and also the surface features such as roads, railroads, houses, streams, mine



Map of Southwestern Wisconsin showing areas surveyed.

and drilling operations, property holders' names, and elevations of all hills. The areas covered are shown on the accomanying map. These areas were selected after consultation with Hon. J. W. Murphy and other prominent mining men, and are the ones most useful for the development of the district.

The field party after its organization was put in charge of Mr. Edward Steidtmann. Under him were four topographer-geologists, two level parties, and a cook, making a party of ten men. The party consisted of the following men:

D. F. Higgins, Topographer and Geologist.
C. E. Decker, Topographer and Geologist.
F. F. Grout, Topographer and Geologist.
Sidney H. Davis, Topographer and Geologist.
Louis Davis, Levelman.
H. A. Stecker, Levelman (part of season).
Edward Stocker, Levelman (part of season).
William Hinn, Rodman.
E. O. Stiehm, Rodman.
Geo. Stocker, Cook.

Mr. Stecker obtained a permanent position during the summer and Edward Stocker was secured in his place.

Two important features of this work are its accuracy and its cheapness. All the level lines which controlled the topography were run in closed circuits which the levelmen were obliged to close with a very small error. Bench marks were set every quarter mile on which the topographers were required to check their barometers at least every two hours, and at shorter intervals as convenient. The barometers were also checked frequently by hand level observations. This care has resulted in very accurate maps.

The cost of the work was $27.50 per square mile. This includes both the field work and preparing the maps for the engraver in the drafting room. The low cost of this work can be appreciated when it is remembered that these maps are on a scale of 4 inches to the mile and show both topography (with 10 foot contours) and geology, and that it costs the U. S. Government about $18 to map a square mile in a much more general way and on a scale of 1 inch to the mile showing no geology and the topography with 20 foot contours.

Uses of the Maps. These maps are of use in two ways in the development of the resources of the districts covered. They

show to the prospector that certain areas are not likely to award his efforts, and so save him money. They also show that other parts of the district are good areas to prospect and so encourage their development.

During the season of 1908 Mr. Hotchkiss has had Mr. G. H. Cox in the field keeping track of the advanced work and making a preliminary study of certain features of the geology in preparation for a complete report which he hopes to be able to begin later.

H. *Work of 1908; Peat.* During the summer of 1908 Mr. Hotchkiss has continued the peat work which was begun in 1903. Prof. Richter was given direct charge of the work and secured Mr. F. W. Huels to collect samples. The testing of these samples will be done under an informal plan of co-operation with the U. S. Geological Survey. It is planned to issue a report on the peat resources of the state at an early date.

General Geology of the State. The only general treatise on the geology of Wisconsin is in the reports of the former survey made in 1873–79. These reports are not generally available and in many cases are superseded by more recent work so there is need for a brief simple statement of what is already known of the geology of the state. Such a bulletin will be of great use as a reference book in high schools, and in general to all citizens who are interested in the resources of the state. Owing to this situation Mr. Hotchkiss has made plans for a bulletin of this character. It will contain chapters on the various phases of the geology of the state written by persons most familiar with each phase. The only part requiring any field work is that on Physical Geography and Mr. Lawrence Martin has put in the field season of 1908 doing field work in preparation for this.

IV. PUBLICATIONS.

At the time of the last biennial report four bulletins were in press and were issued during the year 1907. The complete titles of these bulletins are given in the list of publications at the close of this report.

Bulletin No. XV. Economic Series No. 10. The Clays of Wisconsin and Their Uses. Heinrich Ries.

Bulletin No. XVI. Scientific Series No. 4. The Geology of North Central Wisconsin. Samuel Weidman.

Bulletin No. XVII. Scientific Series No. 5. The Abandones Shore Lines of Eastern Wisconsin. J. W. Goldthwait.

Bulletin No. XVIII. Economic Series No. 11. Rural Highways of Wisconsin. William O. Hotchkiss.

During the year 1908 two bulletins were issued:

Bulletin No. XIX. Economic Series No. 12. Zinc and Lead Deposits of the Upper Mississippi Valley. H. Foster Bain.

Bulletin No. XX. Economic Series No. 13. The Water Powers of Wisconsin. Leonard S. Smith.

Bulletin No. XIX is a reprint of Bulletin No. 294 of the United States Geological Survey. A small edition only has been issued for local use and the bulletin has not been sent out to libraries. Bulletin No. XX has been described on a former page, under the head of *Water Powers*.

V. FUTURE WORK OF THE SURVEY.

The present year has seen a great advance in the forces working toward the conservation and utilization of the natural resources of the country. Very great aid was given to these forces by the recent conference of the governors of the several states, held at Washington, and, as a result of this conference, Wisconsin has appointed a Commission on the Conservation of Natural Resources, of which the Director of this Survey is a member. Much good will doubtless come from this Commission and large results may be expected from its work. But the State of Wisconsin is fortunate in that it appreciated a need for knowledge on the subject of natural resources long before there was a popular movement toward it. More than ten years ago the State established this Survey, by chapter 297 of the laws of 1897. The purposes of the Survey, as set forth in the law, were to collect and diffuse information about the natural resources of the state; animal, vegetable, and mineral. It was to consider the resources themselves; their extent; and the methods of preserving, utilizing and enlarging them. Ores, minerals, soils, forests, and fish are among the subjects committed to it by the statute. It is further charged with the duty of preparing an account of the physical geography and natural history of the state in such form as can be used in schools; and of completing, in connection with the United States Geological Survey, a topographical map of the state. Later statutes, besides imposing other specific duties, have committed to the Survey the subjects of the roads and water powers of the state.

Many of these topics have been treated by the Survey during the past decade. Its first bulletin was on the forest conditions in Northern Wisconsin, prepared by F. Roth in cooperation with the United States Department of Agriculture. Of the non-me-

tallic mineral resources of the state the building stones have been treated by Dr. Buckley (Bulletin No. IV), and two reports, by Dr. Buckley and Professor Ries, (Bulletins Nos. VII and XV) have been issued on the clays. Under the head of economic geology, reports have been issued on the copper-bearing rocks of Douglas County, by Professor Grant (Bulletin No. VI), and three reports on the lead and zinc deposits; two (Bulletins Nos. IX and XIV) by Professor Grant, and one (Bulletin No. XIX) by Dr. Bain, issued in cooperation with the United States Geological Survey. The Baraboo Iron-bearing district was treated by Dr. Weidman in Bulletin No. XIII. A report on the soils and agricultural conditions of North Central Wisconsin was issued (Bulletin No. XI) by Dr. Weidman, covering an area of some 7,200 square miles. Roads have been treated in two reports: one by Dr. Buckley (Bulletin No. X), dealing primarily with the city streets; and one by Mr. Hotchkiss (Bulletin No. XVIII), treating of the rural highways. Four road pamphlets have also been published by the Highway Division. A large part of the water powers of the state are treated in the report of Professor Smith (Bulletin No. XX), which has just been issued.

Thus of the twenty bulletins which the Survey has issued, thirteen have dealt directly with our present natural resources and the means of conserving and improving them. Part of the remainder have been reports which aim to complete the former geological survey of the state. Such are Weidman's report on Pre-Cambrian geology (Bulletin No. III), and especially his large report on the geology of North Central Wisconsin (Bulletin No. XVI). This covers the same area as the soil report, and includes a district which was studied only very superficially, or not at all, by the former Geological Survey, since the region was then unsettled. Another report of the same type is that of Dr. Goldthwait (Bulletin No. XVII) on the glacial geology of the shores of Lake Michigan.

The remaining bulletins have been papers on the physical geography and natural history of the state for the use of schools and the people. The first of these was Peckham's invaluable paper on the solitary wasps (Bulletin No. II), which was followed by Salisbury and Atwood's report on the geography of the Devil's Lake Region (Bulletin No. V) and by that of Fenneman on the lakes of Southeastern Wisconsin (Bulletin No. VIII). The last two named were especially adapted for use in the schools and

found so much favor that they are already out of print. The Survey has ready for the press a revised edition of Bulletin No. VIII.

Much still remains to be done in examining and reporting on those of our present natural resources which this Survey should investigate. Some of the more prominent matters may be mentioned.

1. *Water Powers.* The water powers of the state require much more study. Many of the larger rivers are still unsurveyed. Of these may be mentioned the St. Croix, the Upper Chippewa, the Upper Wisconsin, the Wolf, Oconto, Menomonee, White, Bad, Trempealeau, and the La Crosse Rivers. Those rivers which have been surveyed need much more study. Just at the present time there is a pressing demand from the national government and from the Commission on Conservation for information regarding the water powers. No such data are at hand as are necessary for the information asked. Knowledge of the water powers is required in a completeness and detail which can be supplied only by years of work devoted to stream surveys and gaugings. There can be no doubt that the knowledge thus sought is not only valuable but necessary; yet the Legislature of 1907, though it dealt liberally with the Survey, cut down the appropriation asked for to such a point that the river survey could not be continued. Many of the facts now asked for could have been given had the Legislature thought it wise to give money enough to permit the rapid carrying on of this branch of the Survey.

2. *Southwestern Wisconsin.* The lead and zinc district needs much more study. A glance at the map on page 25 shows that the Survey has made topographical and geological maps of the more important regions where mining is now carried on. These scattered areas should be connected, and a map of the entire district should be published. Several years of field work will be necessary to complete this. This work should be done in advance of exploration, to serve as a guide for the drill men in their search for ores, and not, as has been necessary in the past, allowed to wait until thousands of dollars have been spent in looking for ore in places where there was practically no chance of finding it. The Survey has been able to do very little thus far in the study of the ores and of their origin, and of the manner of their deposition. It cannot be doubted that such study would

lead to scientific results of much value, and also yield, as such work is sure to do, knowledge of great practical importance to prospectors, being helpful to them in developing new districts.

3. *Clays.* While the clays of the state have been explored and reported upon, there is still work which could be done very profitably upon this subject. The nature of our clays renders it improbable that Wisconsin will become a rival of Pennsylvania in the value of its clay products; yet there is no doubt that careful and detailed study would show improved methods of using our clays, and that the value of their products may be greatly increased. This work demands, not a new survey of the clays, but consecutive study of the methods of manufacture, and their relation to the clays; so that methods may be improved, and also that new and more valuable uses may be found for the clays.

4. *Soils.* A matter of even greater importance is that of the examination of the soils of the state, which is suggested on an earlier page, and which can well be carried on by the Survey in cooperation with the College of Agriculture of the University.

I have pointed out that, with the funds at our disposal at present, this work proceeds only very slowly, much more slowly than the interests of the State should permit. There should be such a sum devoted to this purpose as will allow the constant employment of two or three men. That portion of the State which is coming into agricultural use should first be examined. There is an immediate necessity, also, for the examination of that region which may be used as a forest reserve. It is a waste of our resources to employ for the purposes of forestry lands which are of greater value for agriculture, and it is equally unwise to attempt farm operations on lands which are unsuited for profitable use except as forests. When it is remembered that that are thousands of square miles of land coming under these two heads, it must be plain that such a survey cannot be too promptly undertaken or too vigorously pressed.

The extension of such a survey to the southern part of the State would serve different but equally important uses, in guiding the choice of crops, and suggesting the most profitable employment of the soils already occupied by farmers.

5. *Natural History.* The Survey ought to considerably extend its work on the animals of the State, especially on the fish. The latter work should be carried on, and, if possible, with a larger force, as so many important matters still await solution;

but it should also be possible to appoint an assistant who could give his whole time to the preparation of a report on the fish of the state, especially those of the inland waters, dealing with their nature, their distribution, their habits, and their food. This would require several years, but it is important, and fully justifies the time expended upon it.

6. *Educational Bulletins.* The preparation of educational bulletins is a branch of the work which the Survey was directed to undertake, but to which it has been able to devote but little money. Two or, perhaps three such bulletins have been issued, all of which have been very successful. Those on Devils Lake and on the lakes of the southeastern part of the State are now out of print, but the Survey has now in hand the manuscript for a second edition of the last named. Work has been started on a bulletin giving an account of the general geology of the State. This should be pushed to completion, and in addition the Survey ought to be able to extend its work so as to make a complete report upon the physical geography of Wisconsin. Few states of the Union, perhaps, offer larger opportunities for an instructive report on this subject, and the interests of education as well as of science would be greatly advanced by its preparation.

7. *Topography.* In my last biennial report I referred to the necessity of beginning work on the preparation of a topographical map of the state and shall make only brief reference to the matter at this place. The preparation of such a map is one of the duties committed to the Survey by the original law which created it; yet nothing has been done by the State in this direction, since pressing necessities of other branches of investigation gave them precedence. The United States Geological Survey has issued topographical maps covering the southern portion of the state, about as far north as Milwaukee, but this survey is no longer being extended, nor is there reason to believe that much will be done until the State is ready to cooperate with the National Government in the work. A topographical map is something whose necessity does not appear at once, nor does its need appear in any pressing form on any single occasion. In this respect it differs from such a survey as that of the lead and zinc district, where exploration is actively going on and maps are an imperative necessity. Yet the experience of the several states which have prepared a topographic map is that its manifold uses abundantly pay for its cost. Such a map forms a basis for all geological

work and is, as well, a necessity for studies leading to the conservation of soils and swamp lands and of streams and forests. In addition, it possesses great educational value. The preparation of a topographic map requires a good many years and it is all the more necessary that the work should be started at once.

8. *Roads.* I have left to the last one of the most important matters to which the Survey can direct its attention, and one to which it has devoted nearly one-half of its income in the past two years; that of roads. I believe that all will agree that the Survey has wisely expended the money which the last Legislature committed to it for roads, and that the interests of the State have been materially advanced by the expenditure of this comparatively small sum. Plans for the future cannot be definitely suggested at this time, before the vote is taken on the constitutional amendment permitting state aid to roads. I trust and believe that this amendment will be adopted, and that the roads of Wisconsin, whose condition is fundamental to so much of our prosperity, will, before many years, be placed in a condition worthy of so great and wealthy a State.

The Survey has been carefully considering what line of action should be followed by the State, both in the event of the passage of the amendment and in that of its rejection. It is obviously not advisable to submit alternative recommendations at present, but the Survey will be ready to counsel at the proper time with those who will determine the policy of the State.

Very respectfully submitted,

E. A. BIRGE,
Director.

APPENDIX.

FINANCIAL REPORT—FROM SECRETARY OF STATE—GEOLOGICAL SURVEY.

Disbursements, July 1, 1906—June 30, 1907.

Grant, U. S., sal. and exp	830 00	
Hall, E. B., sal. and exp	866 79	
Weidman, S., sal. and exp	2,201 93	
Birge, E. A., sal. and exp	567 69	
Benner, R. C., sal. and exp	531 27	
Hotchkiss, W. O., sal. and exp	1,212 61	
Olson, Olga, services	88 35	
Voorhis, C. T., exp	24 69	
Wagner, George, sal. and exp	389 59	
Juday, Chancey, sal. and exp	1,698 02	
Lenher, Victor, services	288 80	
Tollner, William, services	64 75	
Sanford, F. G., services	220 00	
Severin, H. H., exp	50 93	
Smith, L. S., services	370 00	
Lorenz, E. H. J., services and supplies	34 60	
Neuman, J. J., exp	25 53	
Spencer, Harold, services	82 58	
Jessup, J. M., services and exp	69 45	
Huntley, L. H., services	14 40	
Moss, L. M., services	94 40	
Cramton, B., services	11 38	
Righter, Chester, services	3 65	
Schmidt, R. A., services	18 00	
Brown, P. V., services	7 87	
Leute, Helena, services	10 05	
Webster, Mrs. L. B., services	5 40	
Grimm, J. J., services	7 00	
Allen, Annabel, services	47 90	
Buckley, E. K., services	15 00	
Balsley, H. C., services	22 06	
Hudson, W. D., services and exp	22 00	
Steidtmann, Edward, exp	12 92	
Fisher, A. A., exp	87 80	
Whitall Tatum Co., supplies	47 64	
Parsons Printing & Stationery Co., supplies	99 70	
Birge, E. A., bills paid	626 34	
Hotchkiss, W. O., supplies	5 50	
Haak, Jr., William, supplies	24 68	
Smithsonian Inst., exp	34 65	
Sargent & Co., E. H., supplies	1 39	
Eimer & Amend, supplies	8 20	
Clark Engraving Co., cuts	4,176 12	
Green, H. J., repairs	3 50	
Harris, Samuel, supplies	5 38	
Capital City Paper Co., supplies	11 25	
Spencer Lens Co., supplies	21 00	
American Express Co., expressage	441 89	
U. S. Express Co., expressage	326 48	
Democrat Printing Co., printing	3,407 75	

University Co-operative Store, supplies	34 82	
Park & Saffle Co., rent of typewriter	4 00	
Cantwell Printing Co., printing	12 25	
Wolf, Kubly & Hirsig, supplies	15 00	
Hoen & Co., A., supplies	420 00	
Bien Co., Julius, supplies	157 50	
		$19,083 05
Anderson, John, services	$25 00	
Diestler, G. A., services	237 58	
Dugan, D. H., services	70 00	
Gross, G. E., services	22 50	
Post, F. F., services	22 50	
Reinking, V. H., services	47 07	
Smith, L. S., services	12 00	
		$456 65

Disbursements, July 1, 1907—June 30, 1908.

Allen, Annabel, services	$20 50	
Birge, E. A., director, sal. and exp	1,358 87	
Balsey, F. M., services	38 05	
Brewer, James, services	36 74	
Babcock, J. D., services	20 00	
Cleland, H. F., services	420 75	
Cunningham, J. W., services	30 60	
Davis, S. H., services	122 94	
Davis, L. S., services	114 39	
Decker, C. E., services	205 92	
Dillman, Elsie, services	15 83	
Frankland, Edw., services	5 00	
Grout, F. S., services	122 31	
Grant, W. S., services	30 00	
Gilman, E. D., services	95 30	
Hotchkiss, W. O., geologist, sal. and exp	3,460 04	
Hall, E. B., assistant, sal. and exp	1,334 00	
Hinu, W. H., services	62 99	
Harclerood, J. M., services	15 75	
Higgins, D. F., Jr., services	425 54	
Hagen, Annie, services	23 33	
Hills, E. V., services	85 00	
Hirst, A. R., assistant, sal. and exp	2,329 78	
Hall, R. D., services	109 15	
Halbert, C. A., services	5 60	
Huschka, T. F., services	10 50	
Juday, Chancey, assistant, sal. and exp	676 16	
Jewett, N. L., services	34 50	
Jessup, J. M., services	31 96	
Kingeter, John, services	7 15	
Kemmerer, Geo., services	139 57	
Kuelling, H. J., assistant, sal. and exp	113 13	
Lenher, Victor, services	51 00	
Moreland, Jos., services	4 00	
North, H. B., services	75 00	
Plapp, J. D., services	4 00	
Penn, W. C., services	38 50	
Parker, E. E., services	103 63	
Sanford, F. G., stenographer	310 00	
Steidmann, Edw., sal. and exp	578 91	
Stiehm, E. O., services	65 86	
Smith, J. M., services	18 51	
Stecker, H. A., services	61 05	
Stocker, Geo., services	112 55	
Stocker, Edw., services	43 60	
Tollner, Wm., services	70 56	
Torkelson, M. W., assistant, sal. and exp	709 48	
Vorhies, C. T., services	72 00	
Weidman, S., engineer, sal. and exp	2,430 88	
Wagner, Geo., services	162 76	
Wadsworth, M. H., services	22 00	
Wells, W. C., stenographer	438 71	
American Express Co., expressage	435 81	
Allis Chalmers Co., supplies	5 15	
Abbott, E. P., supplies	29 25	
Baker, A. R., supplies	38 50	
Bausch & Lomb Optical Co., supplies	7 38	
Clark Engraving Co., cuts	371 33	
Cantwell Printing Co., supplies	55 25	
Capital City Paper Co., supplies	21 23	
Democrat Printing Co., printing	4,960 32	
Dietzgen, Eugene, Co., supplies	121 22	
Donohoo, Splinter & Co., supplies	68 93	
Gurley, W. & L. E., supplies	72 26	
Grimm's Book Bindery, supplies	8 34	
Haak, Wm., Jr., supplies	20 10	
Haswell Furniture Co., supplies	114 65	
Johanns, H. J., supplies	143 93	
King Folding Canvas Boat Co., supplies	33 15	
Kny-Scherer Co., The, supplies	25 59	
Lynch, Patrick, supplies	20 00	
Madison Tent & Awning Co., supplies	69 10	
Mandel Engraving Co., supplies	485 55	
Madison P. O., postage	35 52	
N. W. Lithographing Co., supplies	522 76	

Nielson, E. C., supplies	24 00	
Parsons Printing & Stationery Co., supplies	190 40	
Ross, J. M., & Son, supplies	8 25	
Sargent, E. H., & Co., supplies	32 05	
Saffle, C. A., supplies	78 75	
Schmuder, Henry, supplies	13 11	
Sumner & Crampton, supplies	36 40	
Smith & Post Co., supplies	89 00	
Smithsonian Institution, exchanges	19 00	
Smyth, H. A., supplies	6 45	
Tomlinson, W. H., supplies	48 50	
Tyrrell, Jos., supplies	81 07	
United States Express Co., expressage	334 67	
University Co-operative Co., supplies	3 55	
Whitall Tatum Co., supplies	28 98	
Wilkinson & Knapp, supplies	13 05	
Webster, F. R., & Sons, supplies	36 52	
Wauwatosa Stone Co., supplies	21 00	
Yawkey-Crowley Lumber Co., supplies	22 98	
		$25,636 60

STATUTES OF WISCONSIN RELATING TO THE GEOLOGICAL AND NATURAL HISTORY SURVEY.

CHAPTER 297, LAWS OF 1897.

An Act to provide for the investigation of the natural resources of the state of Wisconsin, and providing an appropriation therefor.

The people of the state of Wisconsin, represented in senate and assembly, do enact as follows:

SECTION 1. There is hereby constituted a geological and natural history survey of the state of Wisconsin.

SECTION 2. This survey shall have for its object:

(1) The completion of the geological survey of the state, and especially the examination of the rocks, with reference to the occurrence of iron ores, building stones, and other valuable mineral products, and in reference to their value as material for road construction.

(2) A study of the soils of the state.

(3) A study of the plants of the state, and especially of the forests, with reference to their cultivation and preservation.

(4) A study of the animal life of the state, and especially the occurrence, distribution and production of fish in the lakes and streams of the state, and a study of foods and enemies of fish.

(5) The preparation of an account of the physical geography and natural history of the state, in such form as to serve as manuals for the public schools, and of special reports on subjects of economic importance, in such form as to be of direct service to the people.

(6) The completion of the topographic map of the state begun by the United States Geological Survey; but no money shall be expended for topography unless an equivalent amount be expended for this purpose in the state by the United States government.

SECTION 3. This survey shall be governed by a board of commissioners, consisting of the governor of the state, the state superintendent of public instruction, the president of the state university, the president of the commissioners of fisheries, and the president of the Wisconsin academy of sciences, arts, and letters. The commissioners shall meet within thirty days after the passage of this act, and organize as a commission and adopt by-laws for their government, not inconsistent with law, and shall meet at such time and places as they may prescribe. A majority shall be a quorum. They shall receive no compensation, but each shall be reimbursed his expenses actually and necessarily incurred in the performance of his official duties, out of such appropriation as may be made by the legislature. They shall choose from their number a president, secretary, and such other officers as their by-laws may prescribe; but no officer shall receive any compensation, except such as is herein provided for. The commissioners shall have general charge of the survey, and shall appoint a superintendent of the survey, and, on his nomination, such

assistants and employes as they may deem necessary. They shall fix the compensation of all persons employed in the survey, and may remove them at pleasure.

SECTION 4. It shall be the duty of the commissioners to prepare a report before the meeting of each legislature, showing the progress and condition of the survey, giving an account of money spent together with such other information as may be deemed necessary and useful. The superintendent shall transmit to the commissioners, from time to time, special reports, with necessary illustrations and maps, as these are completed. If approved by the commissioners, they shall be transmitted to the commissioners of public printing, who are authorized to have the reports published in a suitable manner, as independent reports, as bulletins of the state university, or in the transactions of the Wisconsin academy of sciences, arts, and letters, as the commissioners of the survey deem best. If published as independent reports, it shall be the duty of the commissioners of public printing to decide as to the number of copies in the edition of each particular report. Five copies of each report shall be delivered to each of the state officers, and to each member of the legislature. The number of copies provided by law for other public documents shall be furnished to the state historical society, the library of the state university, and other state institutions. The remainder of the independent reports shall be distributed, used in exchange, or sold by the commissioners of the survey, as the interest of the state and of science demands. All moneys obtained by the sale of the report shall revert to the state treasury, as a part of the general fund. Volumes obtained in exchange for the reports shall be added to the library of the Wisconsin academy of sciences, arts, and letters. The superintendent of public property shall furnish, upon the requisition of the president of the commissioners of the survey, such stationery and postage stamps as may be necessary for the use of the commissioners and the superintendent of the survey in official business.

SECTION 5. After material collected shall have served for the purposes of the survey, it shall be distributed to the state university, the colleges of state, the state normal schools, and the free high schools of the state, under the approval of the commissioners of the survey, in such a manner as to be of the greatest advantage to education in the state.

SECTION 6. There is hereby annually appropriated for two years to the commissioners of the geological and natural history survey, out of any money in the treasury not otherwise appropriated, the sum of $5,000, the first appropriation to be paid in the current fiscal year.

SECTION 7. This act shall take effect and be in force from and after its passage and publication.

Approved April 22, 1897.

CHAPTER 163, LAWS OF 1899.

An Act to appropriate a sum of money for the further prosecution of the geological and natural history survey of the state.

The people of the state of Wisconsin, represented in senate and assembly, do enact as follows:

SECTION 1. There is hereby appropriated for the further prosecution of the geological and natural history survey, out of any money in the treasury not otherwise appropriated, the sum of ten thousand dollars annually for the term of two years. This money shall be expended by the commissioners of said survey for the purpose of executing the duties assigned to them by chapter 297 of the laws of 1897.

SECTION 2. This act shall take effect and be in force from and after its passage and publication.

Approved April 12, 1899.

CHAPTER 375, LAWS OF 1901.

An Act to appropriate a sum of money for the further prosecution of the geological and natural history survey of the state.

The people of the state of Wisconsin, represented in senate and assembly, do enact as follows:

SECTION 1. There is hereby appropriated for the further prosecution of the geological and natural history survey, out of any money in the treasury not otherwise appropriated, the sum of five thousand dollars annually. This money shall be expended by the commissioners of said survey for the purpose of executing the duties assigned to them by chapter 297 of the laws of 1897, and any other duties which may be assigned to them by the legislature.

SECTION 2. This act shall take effect and be in force from and after its passage and publication.

Approved May 13, 1901.

CHAPTER 176, LAWS OF 1903.

An Act to appropriate money for the further prosecution of the geological and natural history survey of the state.

The people of the state of Wisconsin, represented in senate and assembly, do enact as follows:

Appropriation of $5,000 additional. SECTION 1. There is hereby appropriated for the further prosecution of the geological and natural history survey of the state, out of any moneys in the treasury not otherwise appropriated, the sum of five thousand dollars annually, in addition to the sum now appropriated by law. This money shall be expended by the commissioners of said survey for the purpose of executing the duties assigned to them by chapter 297 of the laws of 1897, and any other duties which may be assigned to them by the legislature, and especially for the investigation of the clays and clay industries and the completion of the survey of the lead region.

SECTION 2. This act shall take effect and be in force from and after its passage and publication.

Approved May 6, 1903.

CHAPTER 475, LAWS OF 1905.

An Act to provide for ascertaining the amount of available water power in this state and making an appropriation therefor.

The people of the state of Wisconsin, represented in senate and assembly, do enact as follows:

SECTION 1. The geological and natural history survey of the state of Wisconsin is directed to cause survey to be made of the water powers of the state for the purpose of ascertaining the amount of available water power in this state, developed and undeveloped, and the location of the same. Such work may be done in conjunction with the United States geological survey. Upon the completion of such survey a full report thereof shall be made to the governor for the use of the legislature. The sum of two thousand five hundred dollars or so much thereof as may be necessary is hereby appropriated out of any money in the treasury not otherwise appropriated, to defray the expense of such survey.

SECTION 2. This act shall take effect and be in force from and after its passage and publication.

Approved June 20, 1905.

CHAPTER 641, LAWS OF 1907.

An Act to create section 3921 of the statutes, assigning certain duties to the Wisconsin Geological and Natural History Survey, and making an appropriation therefor.

The people of the state of Wisconsin, represented in senate and assembly, do enact as follows:

SECTION 1. There is added to the statutes a new section to read:

SECTION 3921. 1. The Geological and Natural History Survey is directed to investigate and to carry on such experimental work in road building, different methods of construction, kinds of material, and systems of drainage as will enable it to determine upon the various methods of road construction best adapted to the various sections and soils of the state, the cost of the same and recommend standards for the construction of highways in the various sections of the state. It may be consulted by county, city, village or township officers having charge over highways and bridges, and shall when requested advise and give without charge information to such officers relative to the construction, repairing, alteration and maintenance of said highways and bridges.

2. Local road authorities are required to furnish the Geological and Natural History Survey data as to the mileage, cost, maintenance, condition and character of roads under their supervision, upon the written request of and on blank forms supplied by said Geological and Natural History Survey.

3. Said Geological and Natural History Survey is further directed to extend the survey of the lead and zinc region beginning with districts which are at present of greatest economic importance.

4. Said Geological and Natural History Survey is further directed to continue the survey of the water powers of the state. This last survey may be made in conjunction with the United States Geological Survey.

5. Upon completion of the work named, full reports shall be made to the governor for the use of the legislature. The sum of ten thousand dollars annually for two years is hereby appropriated to defray the expense of executing these duties or other duties assigned to the said survey by the legislature.

PUBLICATIONS

OF THE

Wisconsin Geological and Natural History Survey.

---

1. BULLETINS.

The publications of the Survey are issued as (1) bulletins, which are numbered consecutively, (2) road pamphlets, (3) biennial reports, and (4) hydrographic maps. These publications are independently paged and indexed, no attempt being made to group them in volumes.

1. BULLETINS.

The bulletins are issued in three series:

Scientific Series—The bulletins so designated consist of original contributions to the geology and natural history of the state, which are of scientific interest rather than of economic importance.

Economic Series.—This series includes those bulletins whose interest is chiefly practical and economic.

Educational Series.—The bulletins of this series are primarily designed for use by teachers and in the schools.

The following bulletins have been issued:

Bulletin No. I. Economic Series No. 1.

On the Forestry Conditions of Northern Wisconsin. Filibert Roth, Special Agent, United States Department of Agriculture. 1898. Pp. vi, 78; 1 map. *Out of print.*

Bulletin No. II. Scientific Series No. 1.

On the Instincts and Habits of the Solitary Wasps. George W. Peckham and Elizabeth G. Peckham. 1898. Pp. iv, 241; 14 plates, of which 2 are colored; 2 figures in the text. Sold at the price of $1.50 in paper and $2.00 bound.

Bulletin No. III. Scientific Series No. 2.

A Contribution to the Geology of the Pre-Cambrian Igneous Rocks of the Fox River Valley, Wisconsin. Samuel Weidman, Ph. D., Assistant Geologist. Wisconsin Geological and Natural History Survey. 1898. Pp. iv, 63; 10 plates; 13 figures in the text. *Out of print.*

Bulletin No. IV. Economic Series No. 2.

On the Building and Ornamental Stones of Wisconsin. Ernest Robertson Buckley, Ph. D., Assistant Geologist Wisconsin Geological and Natural History Survey. 1898. Pp. xxvi, 544; 69 plates, of which 7 are colored, and 1 map; 4 figures in the text. Sent on receipt of 30c.

Bulletin No. V. Educational Series No. 1.

The Geography of the Region About Devil's Lake and the Dalles of the Wisconsin, with some notes on its surface geology. Rollin D. Salisbury, A. M., Professor of Geographic Geology, University of Chicago, and Wallace W. Atwood, B. S., Assistant in Geology, University of Chicago. 1900. Pp. x, 151; 38 plates; 47 figures in the text. *Out of print.*

Bulletin No. VI. Economic Series No. 3. Second Edition.

Preliminary Report on the Copper-Bearing Rocks of Douglas county, and parts of Washburn and Bayfield Counties, Wisconsin. Ulysses Sherman Grant, Ph. D., Professor of Geology, Northwestern University. 1901. Pp. vi, 83; 13 plates. Sent on receipt of 10c.

Bulletin No. VII. Economic Series No. 4.

The Clays and Clay Industries of Wisconsin. Part I. Ernest Robertson Buckley, Ph. D., Geologist, Wisconsin Geological and Natural History Survey. 1901. Pp. xii, 304; 55 plates. Sent on receipt of 20c.

Bulletin No. VIII. Educational Series No. 2.

The Lakes of Southeastern Wisconsin. N. M. Fenneman, Ph. D., Professor of General and Geographic Geology, University of Wisconsin. 1902. Pp. xv, 178; 36 plates, 38 figures in the text. *Out of print.* A second edition is in press.

Bulletin No. IX. Economic Series No. 5.

Preliminary Report on the Lead and Zinc Deposits of Southwestern Wisconsin. Ulysses Sherman Grant, Ph. D., Professor of Geology, Northwestern University. 1903. Pp. viii, 103; 2 maps, 2 plates, 8 figures in the text. *Out of print.*

Bulletin No. X. Economic Series No. 6.

Highway Construction in Wisconsin. Ernest Robertson Buckley, Ph. D., State Geologist of Missouri, formerly Geologist, Wisconsin Geological and Natural History Survey. 1903. Pp. xvi, 339; 106 plates, including 26 maps of cities. Sent on receipt of 30 cents.

Bulletin No. XI. Economic Series No. 7. Second Edition.

Preliminary Report on the Soils and Agricultural Conditions of North Central Wisconsin. Samuel Weidman, Ph. D., Geologist, Wisconsin Geological and Natural History Survey. 1903. Pp. viii, 67; 10 plates, including soil map. Second edition, 1908. Sent, paper bound, on receipt of 10 cents; cloth bound, 20 cents.

Bulletin No. XII. Scientific Series No. 3.

The Plankton of Lake Winnebago and Green Lake. C. Dwight Marsh, Ph. D., Professor of Biology, Ripon College. 1903. Pp. vi, 94; 22 plates. Sent, paper bound, on receipt of 10 cents.

Bulletin No. XIII. Economic Series No. 8.

The Baraboo Iron-bearing District of Wisconsin. Samuel Weidman, Ph. D., Geologist, Wisconsin Geological and Natural History Survey. 1904. Pp. x, 190; 23 plates, including geological map. Sent, paper bound, on receipt of 10 cents.

Bulletin No. XIV. Economic Series No. 9.

Report on Lead and Zinc Deposits of Wisconsin. Ulysses Sherman Grant, Ph. D., Professor of Geology, Northwestern University. 1906. Pp. ix, 100; 8 plates; 10 figures in the text; and an atlas containing 18 maps. Sent on receipt of 20 cents.

Bulletin No. XV. Economic Series No. 10.

The Clays of Wisconsin and Their Uses. Heinrich Ries, Ph. D., Assistant Professor of Economic Geology, Cornell University. 1906. Pp. xii, 259; 30 plates, including 2 maps; 7 figures in text. Sent on receipt of 18 cents.

Bulletin No. XVI. Scientific Series No. 4.

The Geology of North Central Wisconsin. Samuel Weidman, Ph. D., Geologist, Wisconsin Geological and Natural History Survey. Pp. xxxi, 697; 86 plates, including 2 maps; 38 figures in the text. 1907. Sent on receipt of 40 cents.

Bulletin No. XVII. Scientific Series No. 5.

The Abandoned Shore-lines of Eastern Wisconsin. J. W. Goldthwait, Ph. D., Assistant Professor of Geology, Northwestern University. Pp. x, 134; 38 plates; 37 figures in the text. 1907. Sent on receipt of 15 cents.

Bulletin No. XVIII. Economic Series No. 11.

Rural Highways of Wisconsin. W. O. Hotchkiss, B. S., Instructor in Geology, University of Wisconsin; in charge of Economic Geology, Wisconsin Geological and Natural History Survey. 1906. Pp. xiv, 135; 16 plates; 2 figures in the text. Sent on receipt of 10 cents.

Bulletin No. XIX. Economic Series No. 12.

Zinc and Lead Deposits of the Upper Mississippi Valley. H. Foster Bain. Director of State Geological Survey of Illinois. Washington, D. C. 1907. Pp. xii, 155; 9 plates, including 5 maps; 45 figures in the text. Sent on receipt of 6 cts.

This bulletin is a reprint of Bulletin No. 294 of the United States Geological Survey. *Only a small number of copies were reprinted for local use. It has not been sent out to libraries and exchanges.*

Bulletin No. XX. Economic Series No. 13.

The Water Powers of Wisconsin. L. S. Smith, C. E.; Engineer Wisconsin Geological and Natural History Survey; Engineer U. S. Geological Survey. Pp. xvi, 354; 54 plates; 17 figures in the text. 1908. Sent on receipt of 25 cents.

2. ROAD PAMPHLETS.

Road Pamphlet No. 1.

Earth Roads. Arthur R. Hirst, B. S., Highway Engineer, Wisconsin Geological and Natural History Survey. Pp. 26; 13 figures. Sent on receipt of 2c postage.

Road Pamphlet No. 2.

The Earth Road Drag. Arthur R. Hirst, B. S. Highway Engineer, Wisconsin Geological and Natural History Survey. Pp. 16; 4 figures. Sent on receipt of 2c postage.

Road Pamphlet No. 3.

Stone and Gravel Roads. Arthur R. Hirst, B. S. Highway Engineer, Wisconsin Geological and Natural History Survey. Pp. 27; 11 figures. Sent on receipt of 2c postage.

Road Pamphlet No. 4.

Culverts and Bridges. Arthur R. Hirst, B. S. Highway Engineer, Wisconsin Geological and Natural History Survey. Pp. 47; 16 figures. Sent on receipts of 2c postage.

2. BIENNIAL REPORTS.

The Survey has published six biennial reports, which relate to administrative affairs only and contain no scientific matter.

First Biennial Report of the Commissioners of the Geological and Natural History Survey. 1899. Pp. 31.

Second Biennial Report of the Commissioners of the Geological and Natural History Survey. 1901. Pp. 44.

Third Biennial Report of the Commissioners of the Geological and Natural History Survey. 1903. Pp. 35.

Fourth Biennial Report of the Commissioners of the Geological and Natural History Survey. 1904. Pp. 42.

Fifth Biennial Report of the Commissioners of the Geological and Natural History Survey. 1907. Pp. 45.

Sixth Biennial Report of the Commissioners of the Geological and Natural History Survey. 1909. Pp. 45.

4. HYDROGRAPHIC MAPS.

There have been prepared hydrographic maps of the principal lakes of southern and eastern Wisconsin. This work is in charge of L. S. Smith, C. E., Associate Professor of Topographic and Geodetic Engineering, University of Wisconsin.

The maps are as follows:

		Size of Plate. Inches.	Scale. Inches per mile.	Contour. Interval. feet.
No. 1.	Lake Geneva	17.5x10.8	2	10
No. 2.	Elkhart Lake	15.5x13.1	5	10
No. 3.	Lake Beulah	22.5x20.0	6	10
No. 4.	Oconomowoc-Waukesha Lakes	29.8x19.1	2	10
No. 5.	The Chain of Lakes. Waupaca	21.7x20.6	6	10
No. 6.	Delavan and Lauderdale Lakes	22.5x16.8	4	10
No. 7.	Green Lake	26.0x17.8	3.2	20
No. 8.	Lake Mendata	23.7x19.5	6	5
No. 9.	Big Cedar Lake	18.0x13.5	2.9	10
No. 10.	Lake Monona	17.6x17.3	4	5

In all of these maps the depth of the lakes is indicated by contour lines, and by tints in all except No. 1. They are sent on receipt of 10 cents each except Nos. 4 and 8, for which 15 cents are required. They may be had either mounted in a manilla cover, or unmounted.

All correspondence relating to the survey should be addressed to

E. A. BIRGE, *Director*,
Madison, Wis.